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P281

RELATIONSHIP OF IN VIVO MR T1RHO AND T2 RELAXATION TIMES IN CARTILAGE WITH KNEE OSTEOARTHRITIS

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Purpose: Previous work has demonstrated significantly elevated average T1rho and T2 relaxation times in cartilage for patients with knee osteoarthritis (OA). The goal of this study was to evaluate the relationship of spatial distribution between T1rho and T2 values using z-score maps.
Methods: Ten healthy controls and ten OA patients with clinical OA symptoms and radiologic findings of cartilage degeneration were examined at a 3T GE MR scanner using a transmit/receive knee coil. The image protocol included T1rho mapping sequence; T2 mapping sequence; 3D water excitation high-resolution SPGR images and fat-saturated T2-weighted FSE images. Cartilage was segmented from axial SPGR images. Seven compartments were defined: lateral femur condyle (LFC), medial femur condyle (MFC), lateral anterior femoral (LAF), medial anterior femoral (MAF), lateral patellar (LP), medial patellar (MP), and patella ridge (PR). T1rho and T2 maps were aligned to the SPGR images. T1rho and T2 z-scores were calculated as: Z = (Voxel-Meannormal, comparment)/SDnormal, compartment, where Voxel is the T1rho or T2 in the voxel of interest, Meannormal, comparment and SDnormal, comparment are the mean and standard deviation of T1rho or T2 for all voxels of the normal knees in that compartment derived from controls respectively. The point-to-point correlation between the z-scores of T1rho and T2 in each patients were calculated for each compartments and for overall cartilage using a Pearson correlation.
Results: The median z-score for T1rho and T2 values increased significantly in OA patients (2.14 $\pm$ 0.98 in OA vs. 0.004 $\pm$ 0.69 in controls, P = 0.0003 for T1rho z-scores, and 2.08 $\pm$ 1.44 vs -0.26 $\pm$ 0.50, P = 0.002 for T2 z-scores). The correlation between T1rho and T2 z-scores decreased in OA patients, but the difference was not significant (0.522 $\pm$ 0.183, ranging from 0.221 to 0.763 in OA vs. 0.624 $\pm$ 0.060, ranging from 0.547 to 0.726 in controls, P = 0.173). Figure 1 shows T1rho and T2 maps of a healthy control (upper) and a patient with OA (lower). The correlation coefficients of T1rho and T2 z-scores in this patient was 0.435, 0.598, 0.225, 0.605, 0.477, 0.734, 0.294, 0.289 for LFC, MFC, LAF, MAF, LP, MP and PR respectively.
Conclusions: Cartilage T1rho and T2 values increased significantly in patients with knee OA, which is consistent with our previous studies. The Z-score conversion normalizes the T1rho and T2 values for each subject with the mean value of the control subjects in each defined compartment. In this way differences between cartilage compartments, if exist, can be removed and compared on a common standard, and the T1rho and T2 images may be correlated. T1rho and T2 z-scores had a range of correlations, and at times lower correlation coefficient in osteoarthritic cartilage compared with controls, suggesting these two relaxation parameters may provide complementary information on cartilage degeneration. In vivo T1rho and T2 mapping may be valuable in assessing regional heterogeneity in cartilage degeneration in OA.

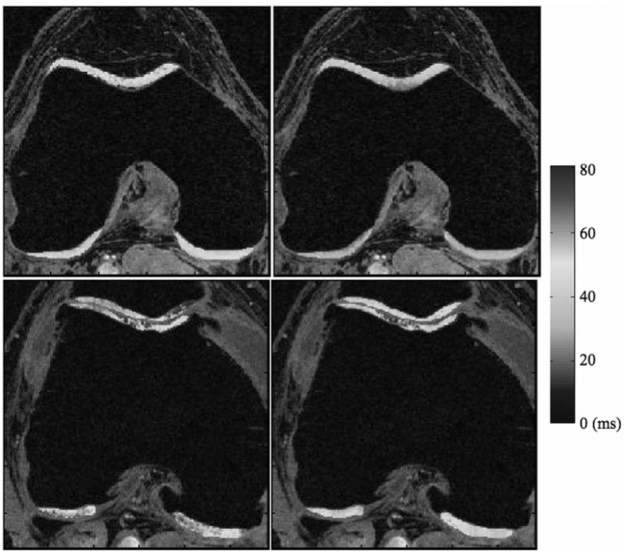

Fig. 1. $T_{1\rho}$ (left) and T_2 (right) maps for a healthy control (upper) and a patient with knee osteoarthritis (lower). The correlation of $T_{1\rho}$ and T_2 z-scores was 0.547 and 0.289 for the control and patient respectively.

P282

ROBUST AUTOMATIC ESTIMATION OF ARTICULAR CARTILAGE SURFACE AREA FROM KNEE MRI

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Purpose: In quantification of articular cartilage from magnetic resonance imaging (MRI) data, cartilage volume and thickness measures are some of the most well established disease markers for osteoarthritis (OA). In this work we explore if the articular cartilage surface area determined from automatic cartilage segmentation of low-field MRI scans can be useful as a disease marker for OA. We evaluate the reproducibility of the area estimate and the ability to detect differences between healthy and OA populations using the cartilage area estimated using a fully automatic segmentation technique.
Methods: We studied 249 knees of which 123 were from healthy subjects and 126 from subjects with mild to severe OA. Healthy subjects were defined as 0 on the Kellgren-Lawrence (KL) index determined from x-rays, and mild to severe OA was defined as KL $>$ 0. The subjects were 21-80 years old with an average age of 56 years, and 45% were females. The subjects were submitted to MRI examination of both knees using an Esaote C-Span low-field 0.18 T scanner performing Turbo 3D T1 sequences with an approximate sagittal slice thickness of 0.8 mm and nearly isotropic voxel size.
31 knees were scanned a second time within a week after the first scan in order to determine inter-scan reproducibility of the area estimate.
A software method for fully automatic segmentation of articular cartilage in MRI data, that separates the voxels into cartilage and background based on prior knowledge of the cartilage structure, was used to estimate the surface area of the medial tibial and femoral cartilage compartments. The estimates were normalized by the size of the tibial plateau.
Results: The cartilage surface area estimate obtained from the automatic method was according to an unpaired t-test significantly lower (p = 0.014) in an OA population than in a healthy population (Fig. 1) when adjusted for difference in bone size. The average total medial tibial and femoral cartilage area was 8200mm^3 for the healthy population and 7900mm^3 for the OA population.
The inter-scan reproducibility for the 31 knees that were scanned